*Rec. West. Aust. Mus.* 1983, 10 (3): 269-306

# A Revision of the Bee Genus *Ctenocolletes* (Hymenoptera: Stenotritidae)

Terry F. Houston*

Abstract

The endemic Australian genus *Ctenocolletes* Cockerell, 1929, is revised with recognition of eight species including four new ones: *C. centralis*, *C. fulvescens*, *C. rufescens* and *C. tricolor*. The male of *C. albomarginatus* and female of *C. ordensis* are described for the first time.

The following are new synonyms: *C. notabilis* Michener, 1965 = *C. nicholsoni* (Cockerell, 1929); *Melitribus glauerti* Rayment, 1930, and *Stenotritus speciosus* Rayment, 1935 = *C. smaragdinus* (Smith, 1868).

*Ctenocolletes murrayensis* Rayment, 1935, is removed to the genus *Stenotritus*. With its removal, *Ctenocolletes* as presently known becomes essentially western Australian in distribution.

Males of some species exhibit allometric variation with larger individuals showing greater convergence of the compound eyes on the vertex.

The species are described, keyed and figured and their distributions are plotted.

## Introduction

Prior to about 1970, few individuals of the endemic Australian genera *Ctenocolletes* Cockerell and *Stenotritus* Smith were to be found in museum collections and revisionary studies at that time would have been premature. In more recent years, more material has come to hand especially from fieldwork in Western Australia and it has become apparent that there are several undescribed species.

These two sister genera have attracted interest because of their uncertain affinities. Until comparatively recently they were regarded tentatively as Colletidae, forming their own subfamily Stenotritinae (Michener 1944, 1965), but McGinley (1980) accorded them family status following studies of glossal morphology.

Recent field studies have also yielded the first observations of the bionomics of *Ctenocolletes* and the present revision provides a sound nomenclatural basis for publication of these observations.

## Methods and Terminology

A total of 266 specimens was examined from collections for which the following abbreviations are used: AM, Australian Museum, Sydney; ANIC, Australian

* Department of Entomology, Western Australian Museum, Francis Street, Perth, Western Australia 6000.

National Insect Collection, CSIRO, Canberra; WADA, Western Australian Department of Agriculture, Perth; WAM, Western Australian Museum, Perth.

The morphological terminology employed here is largely that of Michener (1965) with a few minor departures related to the method of obtaining certain relative dimensions (*vide*).

### Relative Dimensions

All measurements were made using a Zeiss Citoval stereomicroscope with zoom objective and eyepiece graticule with 100 scale divisions. By setting the objective power to give a head width reading of 100 scale divisions for each specimen, all subsequent measurements obtained are equivalent to percentages of head width and are directly comparable between specimens or between species.

The abundant facial hair of most species makes it very difficult to obtain measurements of certain cephalic features and thus they have been omitted from the species descriptions. The methods of obtaining most cephalic measurements used in this paper are illustrated in Figures 1 and 2 and the abbreviations for all measurements are as follows: C2L, length of spur (calcar) of mid tibia; F1L, length of attenuated first segment of flagellum; FRL, length of remainder of flagellum; HL, length of head; HW, width of head; LID, lower interocular distance; MBW, basal width of mandible (viewed ventrally); MFW, minimum width of face (= UID in Figure 1); ML, length of mandible; MOD, diameter of median ocellus; OOD, ocellocular distance; SL, length of scape; UID, upper intercocular distance.

The length of the first segment of the flagellum is measured on the anterior surface (Figure 2) because the distal end is oblique viewed dorsally.

### Propodeal Enclosure

The relative size of the enclosure varies markedly between species and is compared here to the size of the median ocellus. The enclosure's curved margins and tapering extremities preclude easy measurement by other means.

### Terminalia

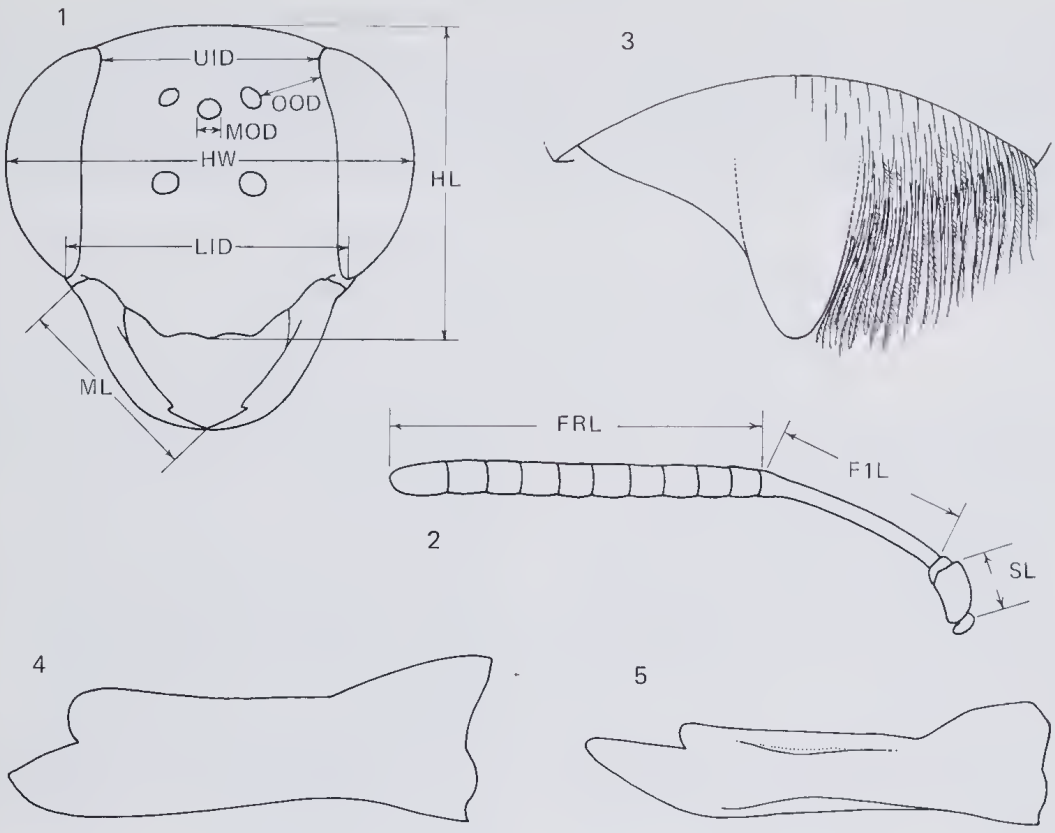
The genital capsule, seventh and eighth metasomal sterna were cleared and immersed in glycerine prior to being drawn.

### Tibial Spurs

Counts of spur teeth include only the coarse teeth and exclude the additional fine teeth that frequently occur proximally. Counts were made on both sides of each bee so that two numbers were obtained from each.

### Vertex

This term is used as is customary for Hymenoptera to mean the summit of the head between the compound eyes even though the ocelli have shifted forward and downward on to the frons.




Figures 1-5 *Ctenocolletes*: (1) head of female and (2) antenna of male of *C. nicholsoni* (anterior views) showing various measurements; (3) apical (7th) metasomal tergum of *C. smaragdinus* male (dorsal view; vestiture omitted from left side); (4) left mandible of *C. fulvescens* female (ventral view); (5) same of *C. nicholsoni* female.

## Systematics

### Family Stenotritidae

### Genus *Ctenocolletes* Cockerell

*Ctenocolletes* Cockerell, 1929: 358. Type-species *Stenotritus nicholsoni* Cockerell, 1929 (monobasic).

Originally established as a subgenus of *Stenotritus* and based solely on female characters, *Ctenocolletes* was first accorded generic status by Rayment (1935: 683; earlier in this book he treated it as a subgenus). Michener (1965) gave it

generic status and differentiated it from *Stenotritus* on the basis of both male and female characters. While some of these have proved reliable, others have not. For example, the number of teeth on the inner hind tibial spurs of females and the size of the propodeal triangle are too varaible and sometimes do not differ from those of some *Stenotritus*. The character states listed in Table 1 distinguish the genera.

Table 1 Character states diagnostic for *Ctenocolletes* and *Stenotritus*.

| *Ctenocolletes* | *Stenotritus* |
|---|---|
| 1 Apical metasomal tergum of male with pygidial plate defined laterally and apically by a carina (Figure 3). | 1 Apical metasomal tergum of male with only a bare area not defined by a carina. |
| 2 Hidden 7th metasomal sternum of male a transverse band (Figures 42, 45, 48), not divided into slender anterior apodemes and setose posterior lobes. | 2 Hidden 7th metasomal sternum of male divided into a pair of slender anterior apodemes and a pair of setose posterior lobes. |
| 3 Labrum of female with an undivided basal elevation (Figures 9-15). | 3 Labrum of female with basal elevation strongly bilobed or grooved medially (Figure 8). |
| 4 Inner hind tibial spur of female with very long coarse teeth and shaft thickest near middle (Figures 22, 23). | 4 Inner hind tibial spur of female with short to moderately long teeth and shaft thickest at base or uniformly thick basally, tapering distally (Figure 21). |
| 5 Apical spine of strigilis of female with long coarse teeth (Figure 17). | 5 Apical spine of strigilis of female with short fine teeth (Figure 16). |

## Species

Michener (1965: 83) listed eight species names under *Ctenocolletes*. Of these, three are here synonymized and one, *C. murrayensis* Rayment, 1935, is removed to the genus *Stenotritus*. The type of the latter in ANIC is a female in poor condition but clearly exhibits the character states for *Stenotritus* given under 3-5 in Table 1. Description of four new species brings the total number of speeies of *Ctenocolletes* to eight.

## Distribution

Western Australia, extreme west of South Australia and probably also western Northern Territory. In Western Australia the genus is mainly confined to the southern portion of the State although *centralis* extends at least as far north as 23°S and *ordensis* is recorded (though dubiously) from the far north. Figures 6 and 7.

## Key to the Speeies of *Ctenocolletes*

1 Head, body and appendages largely bright metallic green ..... *C. smaragdinus*
Head, body and appendages non-metallic, largely black or brown ..... 2

2 Males (antennae 13-segmented) ..... 3
Females (antennae 12-segmented) ..... 8

3 Fore tarsal claws unequal, inner one modified (Figures 27-30); pubescence of mesosoma and metasoma black and white, not buff to rufous ..... 4
Fore tarsal claws equal and alike; pubescence of mesosoma and metasoma chiefly buff to rufous, sometimes partly black and/or white ..... 5

4 Inner fore tarsal claw narrowest at mid section viewed posteriorly (Figure 27); apical (eighth) metasomal sternum not concave near apex (Figure 41); facial pubescence off-white to pale buff ..... *C. albomarginatus*
Inner fore tarsal claw not narrowcst at mid section (Figure 29); apical (eighth) metasomal sternum concave near apex (Figure 44); facial pubescence golden ..... *C. tricolor*

5 Fore basitarsi arcuate (Figures 32, 34); fore trochanters with prominent shiny projections ventrally (Figures 35, 36)..... 6
Fore basitarsi straight; fore trochanters without ventral projections ..... 7

6 Fore trochanters with ventral projections broad basally (Figure 36); hind trochanters without ventroapical projections; mid tibial spur and two hind tibial spurs present ..... *C. nicholsoni*
Fore trochanters with ventral projections constricted basally (Figure 35); hind trochanters each with a slender ventroapical spine (Figure 39); mid tibial spur absent; only one hind tibial spur ..... *C. centralis*

7 Compound eyes converging slightly to strongly above (Figures 53, 54); pubescence of metasomal terga forming distinct bands (Figure 52) ..... *C. rufescens*

Compound eyes not at all converging above; pubescence of metasomal terga not banded, rufous on 1 and 2, black on 3-7 (Figure 51) ..... *C. ordensis*

8 Pubescence of metasomal terga 3-6 entirely black ..... *C. ordensis*
Pubescence of metasomal terga 3-6 not entirely black ..... 9

9 Pubescence of metasomal terga 5 and 6 rufous, contrasting sharply with pure white apical bands on preceding terga ..... 10
Pubescence of metasomal terga 5 and 6 golden to rufous but not contrasting with that of previous segments ..... 11

10 Facial pubescence whitish; labral elevation black; metasomal terga 1-4 with white apical hair bands ..... *C. albomarginatus*
Facial pubescence rufous; labral elevation orange-brown; metasomal terga 1-3 (but not 4) with white apical hair bands ..... *C. tricolor*

11 Mid tibial spur relatively slender with 18-22 short teeth (Figure 19); metasomal terga 2-4 with uniform adpressed golden setae, not conspicuously banded (Figure 49) ..... *C. fulvescens*
Mid tibial spur relatively broad with less than 18 teeth (Figure 20); metasomal terga 2-4 with mainly erect pubescence forming distinct bands (Figures 50, 52) ..... 12

12 Apical plate of hind femur almost entirely covered by dark brown hair (Figure 24); attenuated first segment of flagellum only as long as next 4.5 segments together ..... *C. rufescens*
Apical plate of hind femur only about half-covered by buff or golden setae (Figure 25); attenuated first segment of flagellum at least as long as next 5 segments together ..... 13

13 Ventral margin of clypeus with median prominence (Figure 11); pubescence of scutum and metasomal terga 2-4 usually with patches of blackish setae amongst buff areas (Figure 50) ..... *C. nicholsoni*
Ventral margin of clypeus evenly convex (Figure 10); pubescence of scutum and metasomal terga 2-4 uniformly buff without patches of black setae ..... *C. centralis*


Figure 6 Map of south-western Australia showing collection localities of three species of *Ctenocolletes* (fine lines represent major roads; composite symbols represent coincident records for two species).

## *Ctenocolletes albomarginatus* Michener, 1965

Figures 6, 26-28, 40-42

*Ctenocolletes albomarginatus* Michener, 1965: 266, pl. 5 (1, 2) (female; male only figured).

Holotype

♀, '6 miles N of Watheroo [30°18'S, 116°03'E], W.A., 11.9.1952, McIntosh & Calaby', in ANIC.

Paratypes

Michener designated three female paratypes. Two that I have examined (from Moorine Rock and Merredin) are referable to the new species *C. tricolor*.

### Diagnosis

Agrees with *tricolor* and differs from all other speeies in the following features: fore tarsal claws of male unequal and dissimilar (inner claw modified — Figures 26-28); metasomal integument largely black with white pubescence forming narrow apical bands on terga 1-4 and, in females, contrasting sharply with rufous pubescence of terga 5 and 6.

Distinguishable from *tricolor* as follows: male with inner fore tarsal claw more strongly modified, constricted at midsection viewed posteriorly (not eonstricted in *tricolor*; cf. Figures 27, 28 with 29, 30), and apical (eighth) metasomal sternum not concave near apex (eoncave in *tricolor*); female with glossy black labral elevation (matt orange in *tricolor*); both sexes with off-white to buff faeial pubeseenee (golden in *tricolor*) and a narrow white hair band aeross metasomal tergum 4 (absent from *tricolor*); size smaller.

### Description

*Male*

This sex has not previously been described.

Body length 14-16 mm; head width 4.2-4.9 mm (n 8).

Relative dimensions: HW 100; HL 78-83; UID 32-48; LID 60; MOD 8; OOD 7-11; SL 12-14; F1L 22-23; FRL 77-82; ML 42.

Inner orbits approximately parallel in smaller specimens to slightly converging above in larger ones; vertex varies correspondingly from gently eonvex and higher than tops of eyes to level and slightly lower than tops of eyes; attenuated first segment of flagellum about as long as next 3.2 segments together; labrum rather semieireular, about two-thirds as long as wide, its basal elevation triangular and defined only by a line of setae; first recurrent vein distal to first intercubitus by about one-third posterior length of second cubital cell; propodeal enclosure small, barely large enough to accommodate an ocellus; trochanters lacking projections; fore basitarsus unmodified, straight and about 70% as long as tibia; fore tarsal claws unequal, the inner much longer than the outer and strongly modified (Figures 26-28); hind tibia straight and of elliptical cross-section; hind basitarsus slender with very slightly concave ventral margin; hind distitarsus (exeluding claws) about 75-80% as long as distance from its insertion to base of segment 2; base of seventh metasomal tergum not usually exposed; apieal (eighth) sternum without a strong subapical concavity (Figure 41).

Integument predominantly black with the following orange-brown: mandibles distally, labrum (sometimes), tibiae ventrally (to variable extent) and pygidial plate. Tarsi dark brown.

Facial hair including narrow fringe below labral elevation buff; that of anterior margin of scutum white to faintly buff; white hair on head posteriorly, scutum laterally and posteriorly, metanotum, propodeum, thoracic pleura and sterna (exeept for darker patches on mesopleura and mesosternum), legs proximally to apiees of femora and ventrally on mid and hind tibiae, metasomal sterna 1-4,

tergum 1 and base of 2; apical margins of metasomal terga 2-5 with narrow bands of short white tomentum (weak or incomplete medially); black to dusky grey or brown hair on vertex, scutum except margins, mesonotum from axilla to axilla, tegulae, mesopleura (extent variable), mesosternum and terga 2-6.

Terminalia: see Figures 40-42.

*Female*

Body length 18.0-18.7 mm; head width 5.1-5.7 mm (n 12).

Relative dimensions: HW 100; HL 74-77; UID 51-55 (37 in one); LID 68-70; MOD 7; OOD 15-17 (12 in one); SL 13; F1L 21-22; FRL 54-57; ML 45-52; MBW 14; C2L 24-26.

Form, coloration and pubescence much as described for *tricolor* female except as noted in the diagnosis above and with the following additional differences: mid tibial spurs relatively slender with 16-24 coarse teeth (n 22) most of which are shorter than the shaft is thick; inner hind tibial spurs with 4-10 coarse teeth (n 18); second metasomal tergum with white hair confined to margins, greater part with short black setae; lateral portions of metasomal terga 3 and 4 rather bulbous, translucent dark brown and frequently concealing mites underneath.

Variation: specimens from eastern portion of range (Sandstone, Laverton) have less or no sooty pubescence on scutum and scutellum.

## Distribution

Southern Western Australia (Figure 6).

## Remarks

Although Michener (1965) figured a male, he made no reference to this sex in his description. The sexes are associated here on the basis of their morphological similarities.

### Material Examined

The holotype and the following.

*Western Australia*

12.5 km ENE of Anketell HS (28°02'S, 118°51'E), 6-7 Sept. 1981, T.F. Houston, on flowers of *Baeckea stowardii*, 1 ♀, WAM; 2.5 km NE of Comet Vale (29°57'S, 121°07'E), 9 Sept. 1982, B. Hanich and T.F. Houston, 1 ♂, WAM; Dalwallinu, 11 Oct. 1975, R.P. McMillan, 1 ♀, WAM; 13 miles N of Geraldton, 19 Aug. 1971, T.F. Houston, on flowers of *Scholtzia spathulata*, 2 ♂, WAM; Goongarrie (29°55'S, 121°08'E), Oct. 1980, W.F. Humphreys *et al.*, ex pit fall trap, 1 ♂, WAM; 37 km NE of Laverton, 28°21'S, 122°37'E, 10-12 Sept. 1982, B. Hanich and T.F. Houston, on flowers of *Wehlia thryptomenoides*, 2 ♀, WAM; Merredin, A. Douglas, 2 ♀, WAM; Morawa, 3 Sept. 1978, A.M. and M.J. Douglas, on flowers of *Hakea coriacea*, 1 ♂, WAM; Mullewa, 1 ♂ (19 Aug. 1940, Mules), 2 ♀ (Sept.), WADA; 30 km W of Sandstone (27°59'S, 119°18'E), 7 Sept. 1981, T.F. Houston, 1 ♂ (on flowers of *Eucalyptus oldfieldii*), 1 ♀ (entering burrow in road drain soil), WAM; Watheroo, 1 Sept. 1954, C.F.H. Jenkins, 1 ♀, WADA; Yelbeni, Sept., B. O'Connor, 2 ♂, 1 ♀, WADA; 40 km N of Yuna, 5 Sept. 1981, G.A. Holloway, 1 ♂, AM.

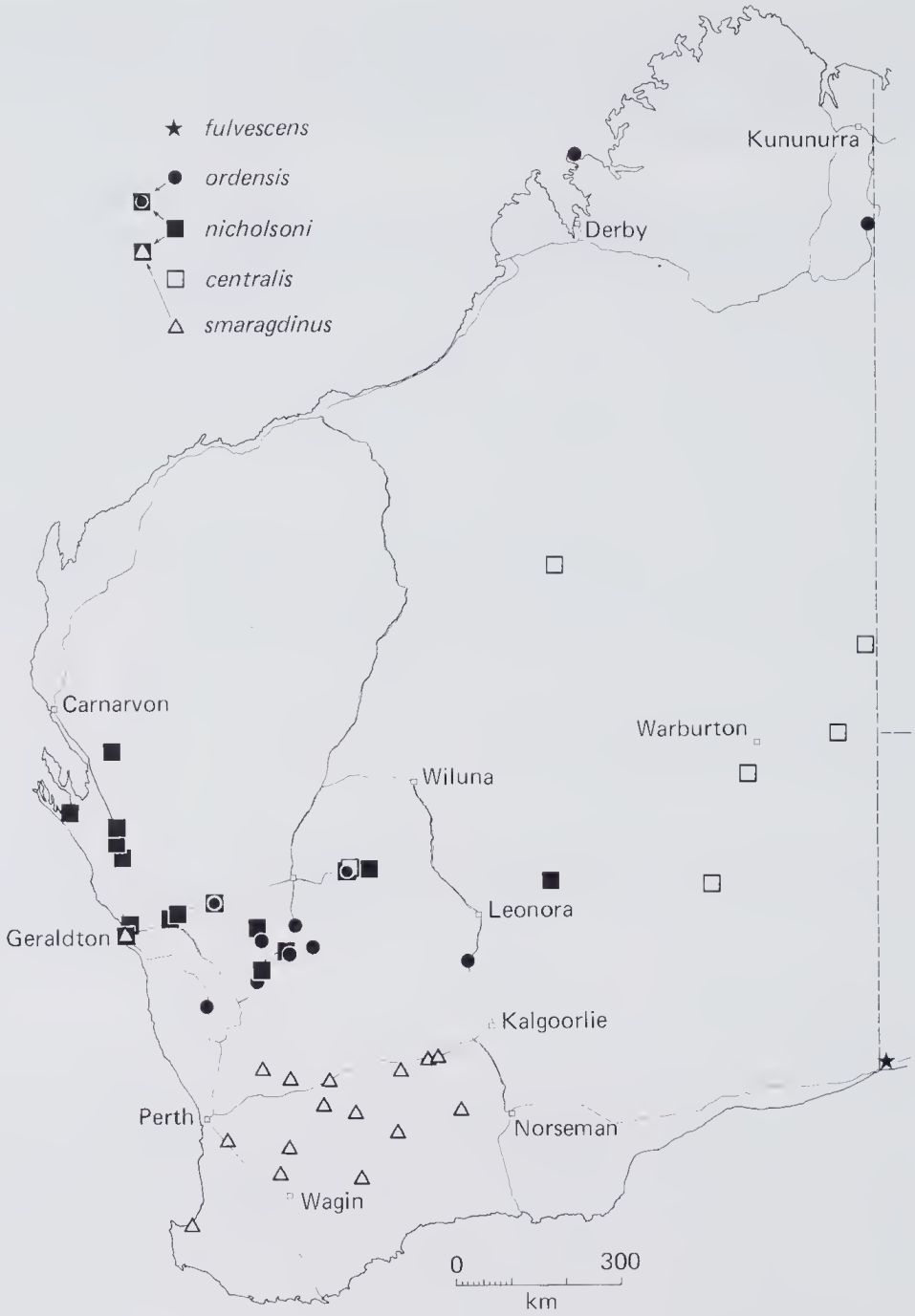
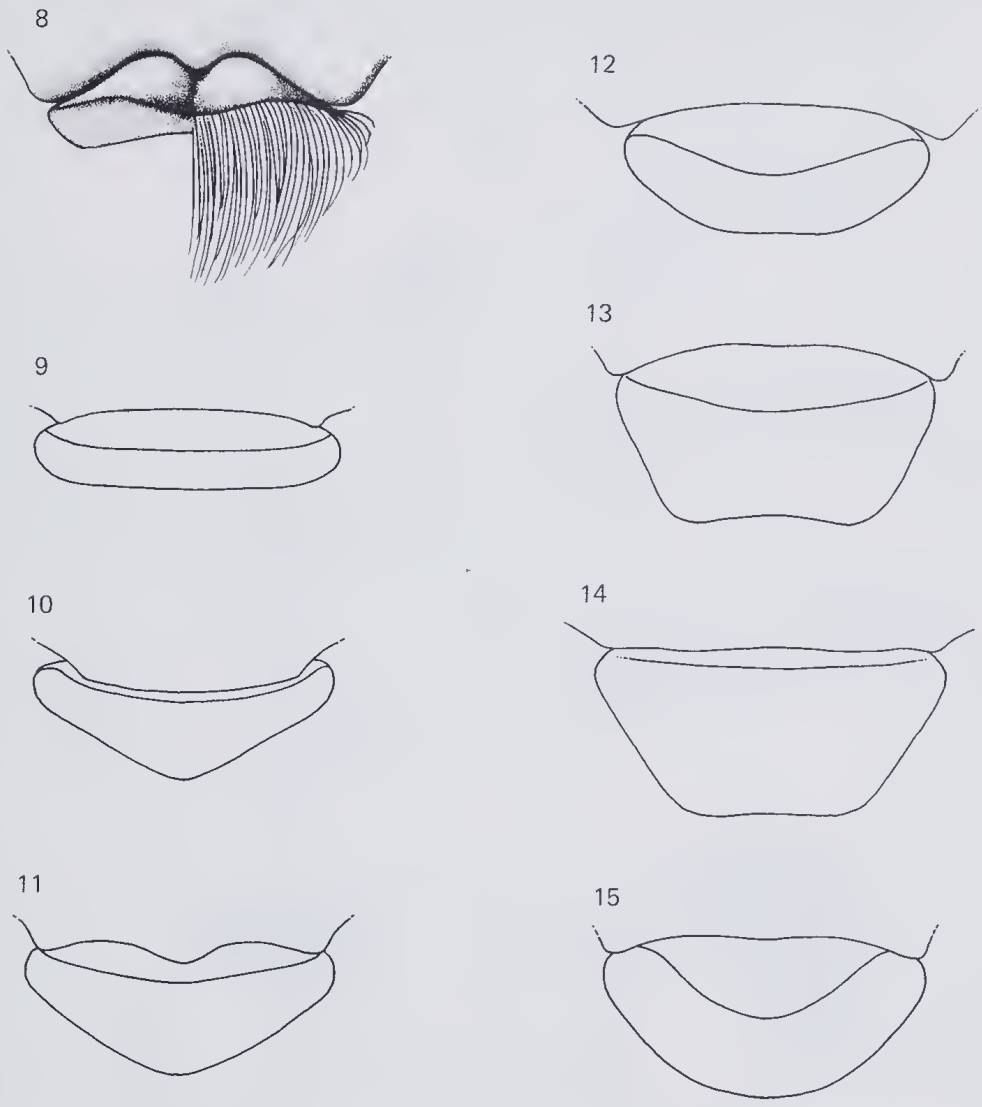
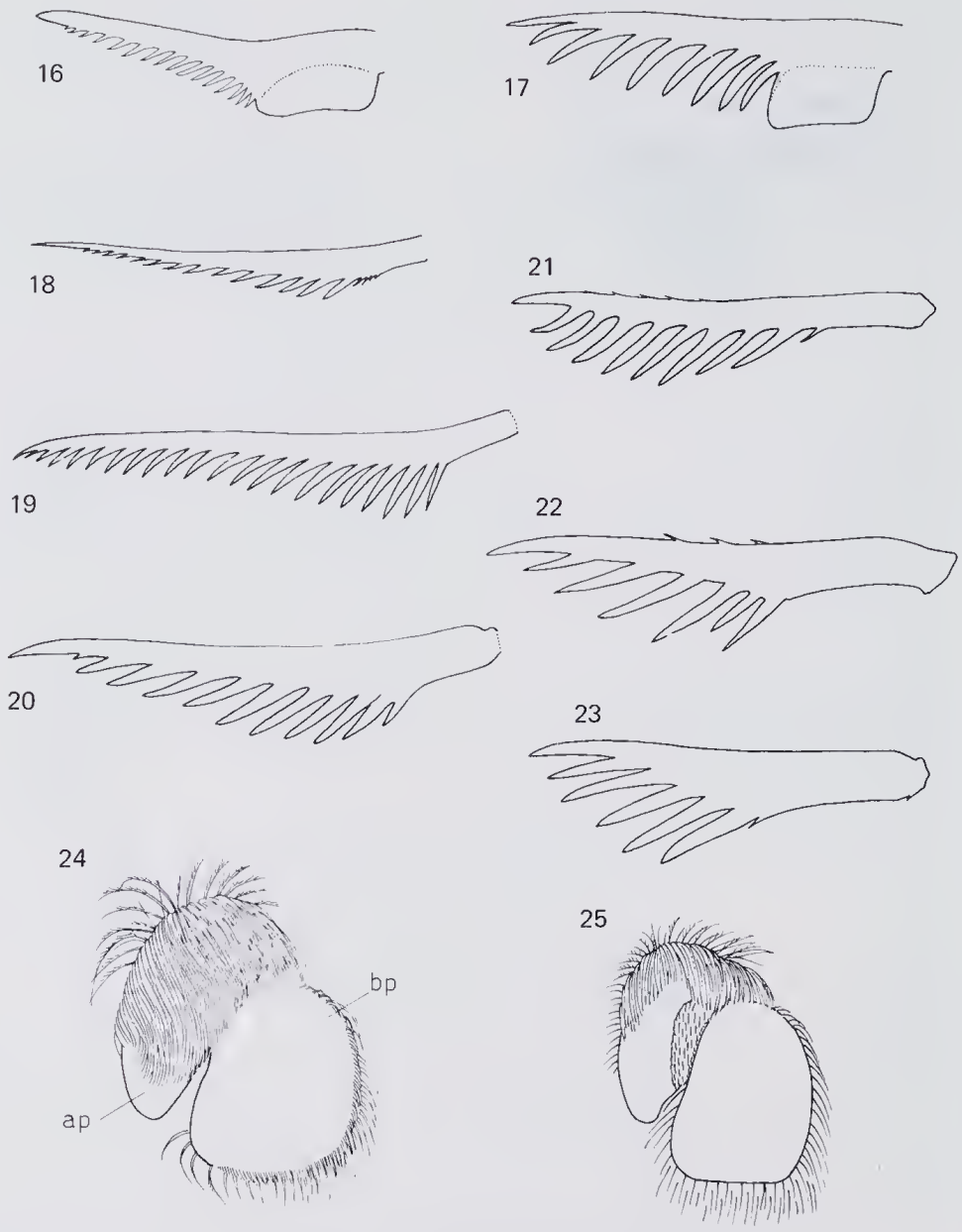


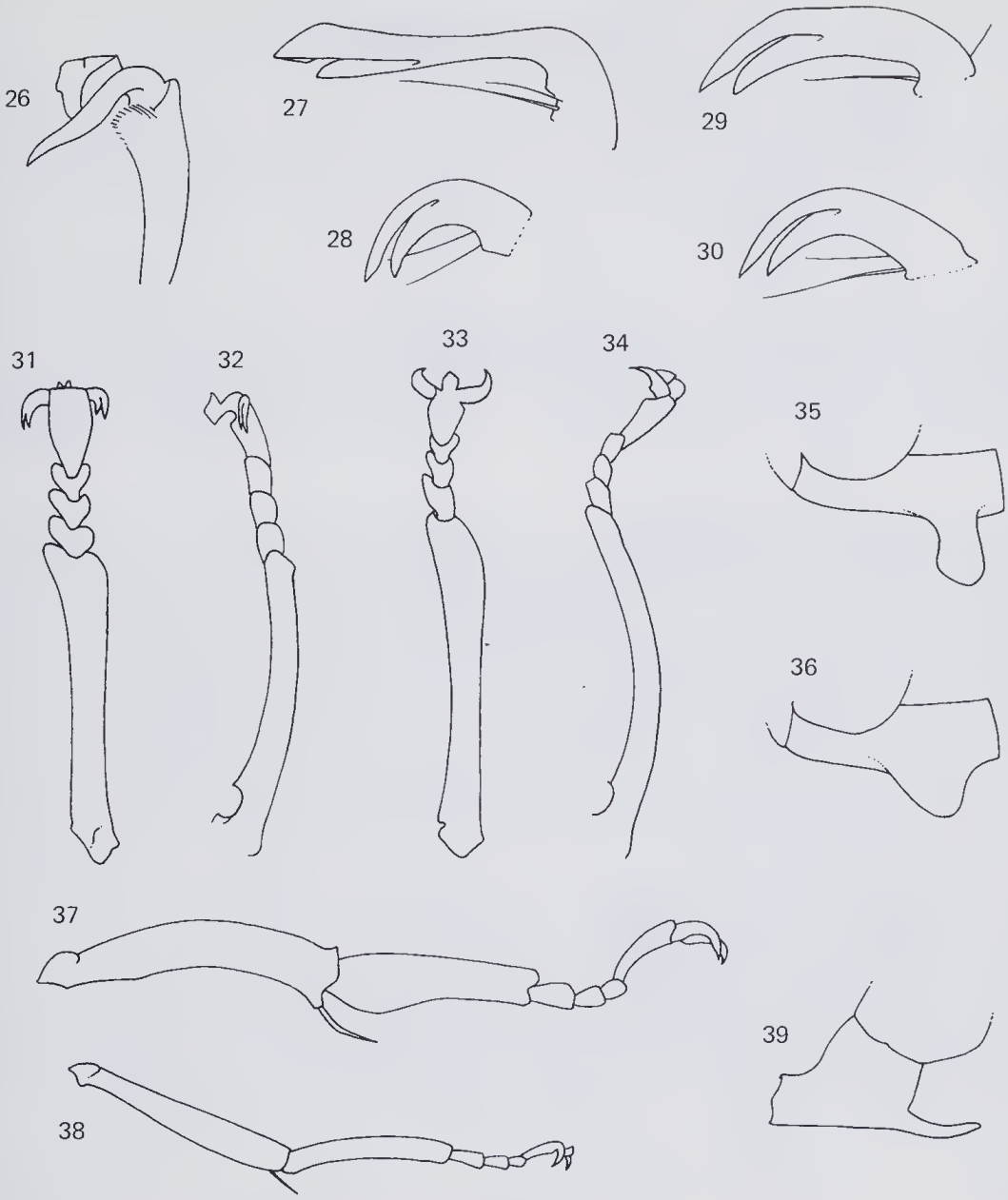

Figure 7 Map of Western Australia showing collection localities of five species of *Ctenocolletes* (fine lines represent major roads; composite symbols represent coincident records for two species).



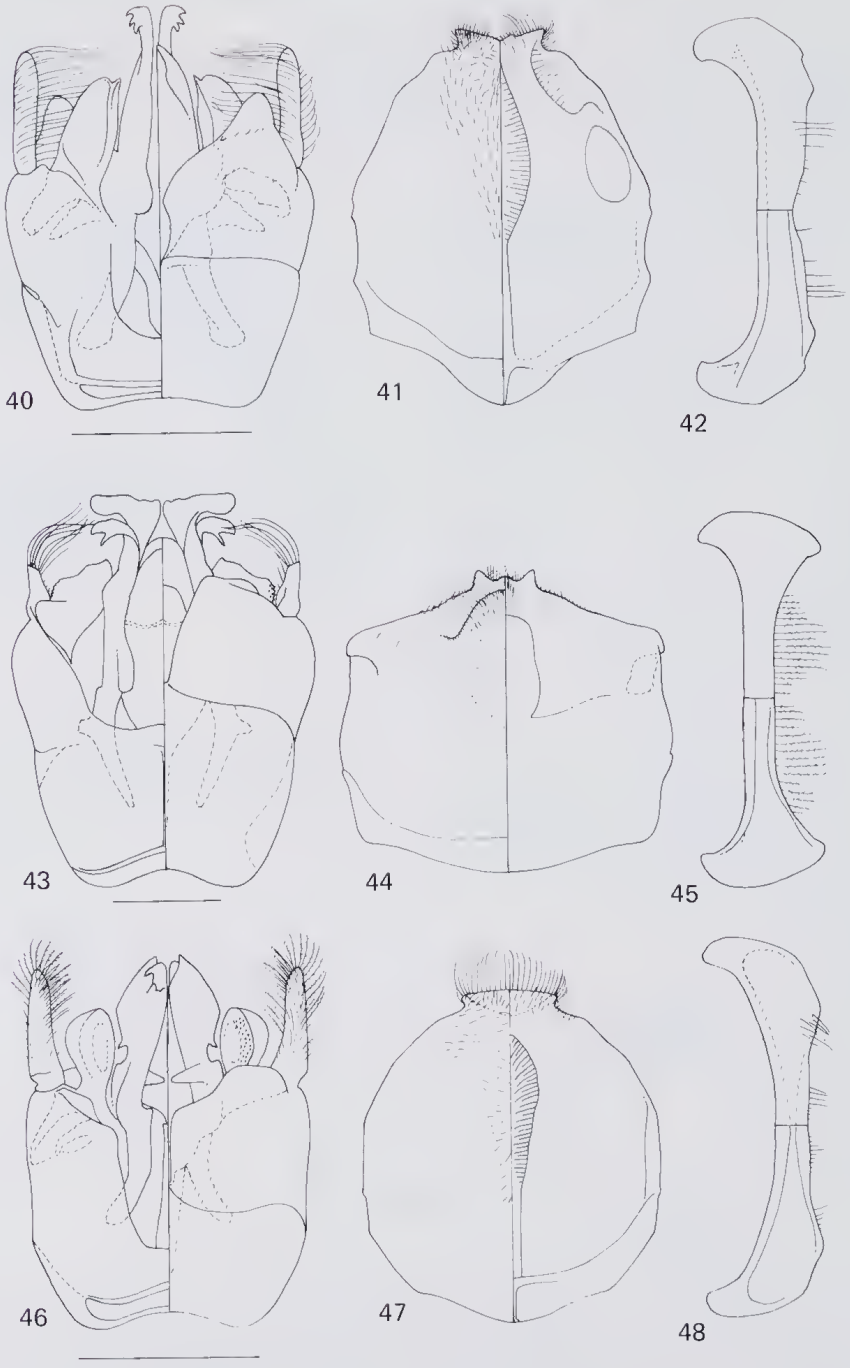

Figures 8-15 Labrum and midventral margin of clypeus of females (anterior views; vestiture omitted except on right-hand side of Figure 8): (8) *Stenotritus greavesi* (Rayment); (9) *Ctenocolletes fulvescens*; (10) *C. centralis*; (11) *C. nicholsoni*; (12) *C. rufescens*; (13) *C. ordensis*; (14) *C. smaragdinus*; (15) *C. tricolor.*




Figures 16-25 Features of legs of females: (16) fore tibial spur of *Stenotritus greavesi*; (17) same of *Ctenocolletes nicholsoni*; (18) mid tibial spur of *C. smaragdinus*; (19) same of *C. fulvescens*; (20) same of *C. nicholsoni*; (21) inner hind tibial spur of *Stenotritus pubescens* Smith; (22) same of *C. ordensis*; (23) same of *C. nicholsoni*; (24) apical plate (ap) of femur and basitibial plate (bp) of left hind leg of *C. rufescens*; (25) same of *C. nicholsoni.*




Figures 26-39 Features of legs of *Ctenocolletes* males: (26) distitarsus of *C. albomarginatus* (inner view); (27, 28) inner and outer fore tarsal claws of same (drawn to same scale); (29, 30) same of *C. tricolor*; (31, 32) dorsal and inner aspects of right fore tarsus of *C. centralis*; (33, 34) same of *C. nicholsoni*; (35) left fore trochanter of *C. centralis* showing ventral process (anterior view); (36) same of *C. nicholsoni*; (37) left hind tibia and tarsus of *C. ordensis* (outer view); (38) same of *C. nicholsoni*; (39) left hind trochanter of *C. centralis* showing ventroapical spine (outer view).




**Figures 40-48** From left to right: genital capsule, 8th and 7th metasomal sterna of *Ctenocolletes* males: (40-42) *C. albomarginatus*; (43-45) *C. tricolor*; (46-48) *C. rufescens*. Dorsal aspect shown on right half of each figure and ventral aspect on left half; 7th sterna rotated 90° clockwise. Scale lines = 1 mm.

## *Ctenocolletes centralis* sp. nov.

Figures 7, 10, 31, 32, 35, 39

**Holotype**

In ANIC, ♂, '3 miles Sth Neale Junction' [28°18'S, 125°49'E], Western Australia, 16 July 1974, K.T. Richards.

**Paratypes**

*Western Australia*

12.5 km ENE of Anketell HS (28°02'S, 118°51'E), 6-7 Sept. 1981, T.F. Houston, on flowers of *Baeckea stowardii*, 2 ♀, WAM; Blackstone Range, 17 July 1967, K.T. Richards, 4 ♀, WADA; Canning Stock Route Well 24, Sept. 1971, R. House, 1 ♀, WADA; same data as for holotype, 4 ♂, WAM, WADA; 130 miles N of Neale Junction, 18 July 1974, K.T. Richards, 5 ♀, ANIC, WADA, WAM.

### Diagnosis

Agrees with *C. nicholsoni* and differs from all other species in the following features: male with fore basitarsi attenuated and arcuate (Figures 31, 32) and fore trochanters with hairless ventral projections (Figure 35); female with apical plate of hind femur only about half-covered with golden pubescence (as in Figure 25); both sexes with attenuated first segment of flagellum at least as long as next five segments together, metasomal terga largely black with erect plumose setae generally and dense, buff bands of pubescence across their hind margins (this last character shared with *C. rufescens*), and first recurrent vein distal to first intercubitus by only one-tenth to one-fifth posterior length of second cubital cell.

Distinguishable from *nicholsoni* as follows: male with ventral projections of fore trochanters relatively longer and more slender, almost elavate (cf. Figures 35, 36), hind trochanters with slender ventroapical spines (Figure 39; absent in *nicholsoni*), mid tibial spur absent and hind tibia with only one spur (mid tibia with one and hind tibia with two spurs in *nicholsoni*); female with mid ventral margin of clypeus evenly convex, not trilobed (cf. Figures 10, 11); both sexes with almost uniformly buff pubescence, lacking conspicuous patches of black or dusky setae (except perhaps on scutellum and axillae).

### Description

*Male* (holotype)

Body length 16 mm; head width 5.3 mm.

Relative dimensions: HW 100; HL 82; UID 23; LID 62; MOD 7; OOD 7; SL 10; F1L 32; FRL 68; ML 40; MBW 11.

Eyes strongly converging above; vertex relatively narrow and depressed below level of tops of eyes (much as in Figure 54); attenuated first segment of flagellum about as long as next 5.5 segments together; first recurrent vein distal to first intercubitus by only about one-tenth posterior length of second cubital cell;

propodeal enclosure relatively large (broad enough to accommodate three ocelli side by side) and extending broadly downwards to propodeal pit; fore coxa with small median ventral projection; fore trochanter with large spathulate ventral projection (Figure 35), hairless at apex, and hind trochanter with slender curved ventroapical spine (Figure 39); fore basitarsus little shorter than tibia, slender proximally, expanded distally and gently arcuate (Figures 31, 32); fore tarsal claws symmetrical; mid tibia lacking spur; hind tibia slender and straight with only one spur and hind basitarsus long and gently arcuate (much as in Figure 38); hind distitarsus (excluding claws) only about 66% as long as distance from its insertion to base of segment 2 (which has a strong ventroapical spine); pygidial plate with slightly elevated carinate margin.

Integument black except as follows. The following are yellow-brown: first segment of flagellum, labrum ventrally, tegulae, wing veins proximally, all tibiae and tarsi. Posterior and lateral margins of metasomal terga hyaline.

Pubescence almost wholly buff to golden-buff, long, erect, plumose, and obscuring underlying integument of most of head and body, densest on face but sparse on vertex and lateral to ocelli; dusky setae occur sparsely on mid scutum, axillae and scutellum and form a distinct transverse band across third and fourth metasomal terga; hind legs have especially long erect pubescence, densest on trochanters.

Terminalia: not significantly different from those of *C. nicholsoni.*

Variation: slight in the small sample available. Head width range 5.25-5.45 mm (n 5), upper interocular distance 16-23% of head width. Eyes in all males strongly convergent with vertex depressed below their summits. Dusky setae are sparse in (or absent from) the mesonotal pubescence of some specimens.

*Female*

Body length 16.5-19.0 mm; head width 5.5-6.0 mm (n 13).

Relative dimensions: HW 100; HL *c.* 75; UID 53-57; LID 65-70; MOD 6; OOD 17-18; SL 11-12; F1L 25-27; FRL 54-56; ML 48; C2L 22-25.

Head distinctly wider than long; face between eyes slightly broader than long; inner orbits parallel to slightly converging above; mid ventral margin of clypeus produced and evenly convex; labrum relatively short with basal elevation hidden beneath clypeus (Figure 10); mandibles slender with acute posterior tooth and small anterior tooth (as in Figure 5); attenuated first segment of flagellum equal in length to next five segments together; propodeal enclosure relatively large as in male; mid tibial spur relatively short (much as in Figure 20) with 8-15 long coarse teeth (n 22); inner hind tibial spur (much as in Figure 23) with 3-7 very long coarse teeth (n 21); pygidial plate broadly triangular with even surface.

Integument predominantly black. The following are brown: tegulae, wing veins proximally, fore and mid distitarsi, hind tibiae and tarsi, tibial spurs, swollen translucent lateral portions of metasomal terga 3 and 4 (which often conceal mites underneath), and pygidial plate. Hind margins of metasomal terga hyaline.

Pubescence generally moderately dense, erect, grading from white on lower face and posterior of head, through pale buff on lateral and ventral areas of thorax and propodeum, buff on upper face, dorsum of thorax, tegulae and most of metasoma, to golden on fifth and sixth terga. Blackish setae occur moderately densely across vertex, on axillae and scutellum but only very sparsely on central scutum and do not form a colour patch on the latter. A band of dense buff pubescence occupies full width of vertex above ocelli. Labrum lacks pubescence. Apical plate of hind femur at least half bare (as in Figure 25), remainder covered by golden setae. Metasomal terga 1-4 with dense apical bands of pale buff pubescence contrasting with sparser more erect setae elsewhere.

**Distribution**

Central desert region of Western Australia (Figure 7).

**Remarks**

This species is sympatric with its nearest relative, *nicholsoni*, near Sandstone but no evidence of hybridization has been noted. The sexes are associated on the basis of morphological similarity and correlation of characters with those of *nicholsoni*.

The specific epithet alludes to the distribution of the species.

## *Ctenocolletes fulvescens* sp. nov.

Figures 4, 7, 9, 19, 49


Figure 49 *Ctenocolletes fulvescens* female (holotype).

**Holotype**

In WAM (82/818), ♀, '20 mi. NE of Eucla [Western Australia, 31°41'S, 128°54'E]', South Australia, 21 January 1970, T.F. Houston, on flowers of *Eucalyptus oleosa* at sunrise. The type locality is in S.A. about 18 km from the W.A. border.

### Diagnosis

Female (male unknown) distinguishable from those of all other species by the following features: dorsum of thorax covered by dense erect tomentum imparting an overall buff colour, each seta white with dark brown tip; metasomal integument yellow-brown dorsally, second to fourth terga with adpressed golden simple setae, others with longer golden pubescence but conspicuous banding absent (Figure 49); inner hind tibial spurs with ten coarse teeth.

### Description

*Female* (holotype)

Body length 18 mm; head width 6.2 mm.

Relative dimensions: HW 100; HL 81; UID 46; LID 70; MOD 7.5; OOD 15; SL 14; F1L 22; FRL 55; C2L 35.

Head appearing only slightly wider than long and face longer than wide; compound eyes converging slightly above; mid ventral margin of clypeus fairly straight; labrum relatively very short, basal elevation occupying half its length (Figure 9); mandible relatively stout with broad anterior tooth (Figure 4); attenuated first segment of flagellum as long as next four segments together; mid tibial spurs relatively long, moderately slender and with 18-22 stout teeth (Figure 19); inner hind tibial spurs very broad with ten long stout teeth; first recurrent vein distal to first intercubitus by about one-third posterior length of second cubital cell; propodeal enclosure moderately large, more than ample to accommodate an ocellus; lateral portions of metasomal terga 3 and 4 ordinary (not bulbous); pygidial plate with a strong median convexity.

Integument black to dark brown except for the following areas of yellow-brown: transparent tegulae, metasomal tergum 1 apically and terga 2-4 dorsally, flagella ventrally, distal tarsal segments and hind basitarsi, and all tibial spurs.

Long white plumose setae generally dense enough to obscure underlying integument (except upper portion of clypeus) occurs as follows: face up to ocelli, head posteriorly, fringe beneath labral elevation, lateral, ventral and posterior surfaces of mesosoma (posterior surface of propodeum has much shorter setae contrasting sharply with very long setae of posterolateral areas), proximal portions of legs and metasomal sterna 1-5. Vertex with sparse dusky brown setae. Dorsum of thorax with short, dense, erect tomentum, each seta white with a dark brown apex, colour overall appears buff; scutellum with two bare areas (possibly worn). Metasomal terga with golden pubescence (except bare anterior face of first); dorsal surface of tergum 1 with short erect plumose setae, terga 2-4 with adpressed simple setae not obscuring integument, 5 and 6 with long dense plumose setae· apical margins of terga 1-4 have very narrow fringes of paler plumose setae but metasoma does not appear banded (Figure 49); foveal areas of tergum 2 covered by short buff tomentum. Apices of hind femora covered by dense buff setae. Hind tibiae and tarsi with predominantly white setae on outer sides (brownish near basitibial plates), yellow-brown on inner sides of basitarsi.

### Remarks

Known only from the type specimen.

Because of its relatively large propodeal enclosure and numerous teeth on the inner hind tibial spurs, this species would run to *Stenotritus* by Michener's (1965) diagnosis and key. However, the form of its tibial spurs and labrum clearly ally it with other *Ctenocolletes*.

The specific epithet is Latin for 'becoming golden' in allusion to the metasomal pubescence.

## *Ctenocolletes nicholsoni* (Cockerell, 1929)

Figures 1, 2, 5, 7, 11, 17, 20, 23, 25, 33, 34, 36, 38, 50

*Stenotritus (Ctenocolletes) nicholsoni* Cockerell, 1929: 358-359.
*Ctenocolletes nicholsoni* (Cockerell) Michener, 1965: 83.
*Ctenocolletes notabilis* Michener, 1965: 266-267, pl. 5 (3), text figures 220-222. Syn. nov.

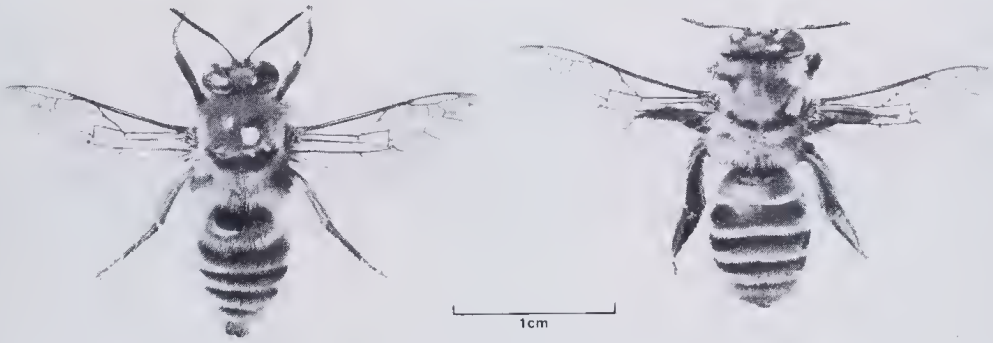



Figure 50 *Ctenocolletes nicholsoni* male (left) and female.

### Types

Holotype of *nicholsoni:* ♀, Kojarena [28°44'S, 114°52'E], Western Australia, 8 September 1926, Nicholson, in AM.

Holotype of *notabilis:* ♂, Geraldton [28°46'S, 114°37'E], Western Australia, 1917, W.W. Froggatt, in ANIC.

### Diagnosis

Most like *C. centralis* and rather similar to *C. rufescens*. For differences refer to diagnoses of those species.

### Description

*Male*

Body length 17-19 mm; head width 5.1-5.5 mm (n 11).

Relative dimensions: HW 100; HL 80-82; UID 20-24; LID 60-62; MOD 7; OOD 6.0-7.5; F1L 34; FRL 66-70; SL 10; ML 43.

Form and pubescence much as described for male of *C. centralis* differing as noted in diagnosis of that species and in the following additional ways.

Fore basitarsi more strongly arcuate and not quite as expanded distally (Figures 33, 34); no ventroapical spine on second segment of hind tarsus.

Pubescence more varied in coloration than in *centralis*. Rich buff on face and anterior portion of scutum, contrasting with whiter hair on posterior of head, posterior of scutum, metanotum, propodeum and first metasomal tergum. Black or dusky brown setae form dark patches as follows: a pair of rounded patches on mid scutum, smaller patch posteriorly on tegula and on mesopleuron below tegula, band across scutellum and axillae, dorsolateral patches on propodeum and wide transverse bands across metasomal terga 2-5 (that on 2 sometimes faint to virtually absent); dense buff more adpressed pubescence forms conspicuous cross-bands on hind margins of terga 2-5; pubescence of hind trochanters no denser than elsewhere and hind tibiae with dusky brown setae dorsally.

Terminalia: figured by Michener (1965: 84).

*Female*

Body length 18.0-20.5 mm; head width 5.7-6.3 mm (n 22).

Relative dimensions: HW 100; HL 75-77; UID 51-55; LID 67-69; MOD 5.5-6.5; OOD 16-17; SL 12-13; F1L 26-27; FRL 53-56; ML 44-49; C2L 22.

Form, coloration and pubescence as described for *centralis* female except as noted in the diagnosis of that species and with the following additional differences.

Labrum sub-triangular with basal elevation exposed (Figure 11); mid tibial spur (Figure 20) with 8-13 coarse teeth (n 42), inner hind tibial spur (Figure 23) with 3-5 coarse teeth (n 36).

Pubescence white on lower face, posterior of head, lateral and ventral areas of thorax (except sooty patch on mesosternum), propodeum and proximal portions of legs; vertex with buff pubescence usually confined to area above ocelli and not obscured by it from front; black or sooty brown setae form patches as follows — band across vertex, wide band across scutum extending laterally narrowly in front of tegulae, band across scutellum and axillae, patch on mesopleuron below tegula, faint dorsolateral patches on propodeum, and all but apical margins of metasomal terga 2-4; dense apical fringes of metasomal terga grading from pale buff on 1 to fulvous on 5 and 6.

Variation: sooty areas of pubescence decrease in extent and intensity towards eastern part of range; almost absent form thorax and metasoma of Laverton specimens.

**Distribution**

Southern Western Australia (Figure 7).

## Remarks

The sexes have been confidently associated on the basis of morphological similarities, coincident collection records and correlation of characters with those of the closely related *C. centralis*.

### Material Examined

The holotypes of *nicholsoni* and *notabilis* and the following.

*Western Australia*

11 km ENE of Anketell HS (28°02'S, 118°51'E), 4-6 Sept. 1981, T.F. Houston, on flowers of mulga *Acacia*, 1 ♀, WAM; 12 km NNE of Eurardy HS (27°34'S, 114°40'E), 19 Aug. 1980, C.A. Howard and T.F. Houston, on flowers of *Acacia blakelyi*, 1 ♀, WAM; 126 miles N of Geraldton, 20 Aug. 1971, T.F. Houston, on flowers of *Baeckea pentagonantha*, 2 ♂, 7 ♀, WAM; 37 km NE of Laverton, 28°21'S, 122°37'E, 10-12 Sept. 1982, B. Hanich and T.F. Houston, on flowers of *Wehlia thryptomenoides*, 2 ♀, WAM; 10 km ESE of Meedo HS (25°40'S, 114°37'E), 23-26 Aug. 1980, C.A. Howard and T.F. Houston, on flowers of *Calytrix oldfieldii*, 1 ♂, 1 ♀, WAM; Meleya Well (28°58'S, 117°12'E), Thundelarra Stn, 28 Aug.-2 Sept. 1981, T.F. Houston, on flowers of *Acacia tetragonophylla*, 3 ♀, WAM; Moresby Range, Geraldton, 7 Aug. 1974, N. McFarland, 2 ♂, 1 ♀, WADA; Mullewa, L.J. Newman, 3 ♀, WADA; 10 km E of Mullewa, 17 Aug. 1981, P.G. Kendrick, 2 ♂, WAM; 16 km S of Nerren Nerren HS (27°08'S, 114°38'E), 19 Aug. 1980, C.A. Howard and T.F. Houston, on flowers of *Scholtzia drummondii*, 2 ♂, 1 ♀, WAM; 10 km SW of Paynes Find, 29 Aug. 1981, G.A. Holloway, 2 ♂, 2 ♀, AM; RP[?], 3 Aug. 1973, D. and N.F. McF[arland], 1 ♂, WADA; Sandstone, 28 Aug. 1974, A.M. and M.J. Douglas, 10 ♀, WAM; 8 km NE of Tamala HS (26°42'S, 113°43'E), 21-23 Aug. 1980, C.A. Howard and T.F. Houston, on flowers of *Scholtzia drummondii*, 4 ♀, WAM; same as preceding but on flowers of *Ptilotus obovatus*, 1 ♂, WAM; 70 km NE of Wubin, 28 Aug. 1981, G.A. Holloway, at light, 1 ♀, AM; 28 km W of Yalgoo, 1-2 Sept. 1981, G.A. Holloway, 2 ♂, AM.

## *Ctenocolletes ordensis* Michener, 1965

Figures 7, 13, 22, 37, 51

*Ctenocolletes ordensis* Michener, 1965: 267, pl. 5 (4), figures 217-219.

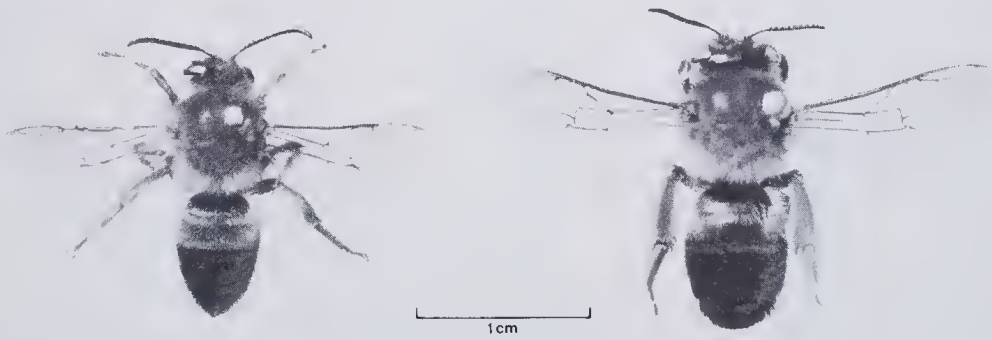



Figure 51 *Ctenocolletes ordensis* male (left) and female.

Type

Holotype: ♂, 'Wotjulum' [16°07'S, 123°43'E], Western Australia, 3 October 1955, A.M. Douglas, in WAM (65/728).

See under Remarks concerning veracity of type locality.

## Diagnosis

Readily distinguished from all other species by the following features: pubescence of head, mesosoma, first two metasomal terga and legs predominantly orange-brown without patches of darker setae; metasomal terga 2-6 shining black, without bands of pale pubescence and with only black setae (Figure 51); fore legs of male ordinary but hind tibiae curved (Figure 37), with a flat ventral surface and outer spurs bent near middle; female with relatively elongate inner hind tibial spurs (Figure 22).

## Description

*Male*

Body length 14.0-16.5 mm; head width 4.6-4.9 mm (n 10).

Relative dimensions: HW 100; HL 79-83; UID 48-51; LID 60; MOD 7-8; OOD 11-13; SL 14; F1L 23-24; FRL 95-102; ML 42-43.

Head fairly rounded in anterior view; inner margins of eyes approximately parallel, face between them about 1¼ times as long as broad; vertex gently convex and elevated above summits of eyes; labrum much as in female (Figure 13) but with weak elevation; mandible slender with long acute posterior tooth; attenuated first segment of flagellum as long as next 3 segments together; first recurrent vein distal to first intercubitus by 30-40% posterior length of second cubital cell; propodeal enclosure about large enough to accommodate an ocellus; fore and mid legs unmodified; hind tibiae curved with ventral surface longitudinally concave and transversely flat and spurs bent (Figure 37); hind basitarsi almost as broad as tibiae; hind distitarsus (excluding claws) slightly longer than distance from its insertion to base of segment 2 (Figure 37).

Integument of head and body almost wholly black, most shining on metasomal terga. The following are orange-brown: flagella ventrally, labrum, all legs beyond trochanters, tegulae, proximal portions of wing veins and pygidial plate.

Pubescence of head, mesosoma, first two metasomal terga and legs golden-brown to buff, mostly long and obscuring integument; labrum with a fringe of plumose setae arising under elevation; metasomal terga 3-7 with short, simple to long plumose black setae.

Terminalia: figured by Michener (1965: 84).

*Female*

This sex has not previously been described.

Body length 17.0-18.5 mm; head width 5.5-5.8 mm (n 10).

Relative dimensions: HW 100; HL 75-78; UID 56-60; LID 67-69; MOD 7; OOD 16-17; SL 14; F1L 22-23; FRL 61-65; ML 48; MBW 14-16; C2L 26-27.

Inner margins of eyes more or less parallel, face between them about as broad as long; vertex strongly elevated above summits of eyes, rather transverse medially; midventral margin of clypeus excavated but mostly transverse; labrum long, truncate apically and with broad basal elevation occupying about one-third of length (Figure 13); mandible strongly broadened subapically with acute, tapering posterior tooth and much smaller anterior tooth; attenuated first segment of flagellum as long as next 3.5-3.7 segments together; wing venation as in male; propodeal enclosure large enough to accommodate only one ocellus; lateral portions of metasomal terga 3 and 4 ordinary (not bulbous, translucent or concealing mites); pygidial plate longer than broad and usually narrow at apex, surface even; mid tibial spurs slender with 13-20 short teeth (n 20); inner hind tibial spurs relatively slender (Figure 22) with 4-6 coarse teeth (n 13).

Integumental coloration and pubescence much as in male but buff pubescence of metasomal terga 1 and 2 sparse and inconspicuous except over foveal areas; basitibial plates dark brown.

## Distribution

Southern inland (mulga shrubland) area of Western Australia (Figure 7). Records of the species from the far north of W.A. (including the types) are regarded as probable errors (see Remarks).

## Remarks

The sexes are associated on the basis of their distinctive pubescence and coloration and on the basis of coincident collection records.

The name *ordensis* was proposed in manuscript by Rayment but never published by him.

In view of a separation of over 1 300 km between the bulk of collection localities and those in the far north, the reputed collector of the type, A.M. Douglas, was asked if he could verify its provenance. He was unable to do so. The climate and ecology of the far northern localities and the southern range would be very different and yet I cannot detect any differences between specimens recorded from the two areas. Unless new northern records are obtained I would regard the earlier ones as incorrect.

### Material Examined

The holotype and the following.

*Western Australia*

11 km ENE of Anketell HS (28°02'S, 118°51'E), 4-6 Sept. 1981, T.F. Houston, at nests, 9 ♀, WAM; Marchagee Nature Reserve near Coorow, 21 Aug. 1982, M. Powell, 1 ♀, WAM; 4 miles NE of Menzies, 2 Sept. 1971, T.F. Houston, on flowers of *Scaevola spinescens*, 2 ♀, WAM; 'Ord R., Nov. 1951', 2 ♂ [the specimens also bear Rayment paratype labels with his unpublished combination of the specific epithet with *Gastropsis*], ANIC; 25 miles E of Paynes Find, 23 Aug. 1964, W.H. Butler, 23 ♂, WAM; 50 km N of Paynes Find, 16 Aug. 1981, P.G. Kendrick, 1 ♀, WAM; 10 km S of Paynes Find, 10 Sept. 1982, M. Powell, on flowers of

*Grevillea* sp., 1 ♂, WAM; 6 km ENE of Warriedar HS (29°08'S, 117°11'E), 27 Aug. 1981, T.F. Houston, on flowers of *Scaevola spinescens*, 1 ♀, WAM; 13 km NE of Warriedar HS, 28 Aug. 1981, T.F. Houston, on flowers of *Cassia chatelainiana*, 1 ♂, WAM; same data as for type but dated 9 Oct., 1 ♂ (paratype), WAM; 55 km NE of Wubin, 9 Sept. 1982, M. Powell, on flowers of *Grevillea* sp., 1 ♀, WAM; 28 km W of Yalgoo, 2 Sept. 1981, G.A. Holloway, 2 ♂, 2 ♀, AM.

## *Ctenocolletes rufescens* sp. nov.

Figures 6, 12, 24, 46-48, 52-55


Figure 52 *Ctenocolletes rufescens* male (left) and female.

### Holotype

In WAM (81/691), ♂, Balline Station [Homestead at 27°59'S, 114°13'E], Western Australia, 24-25 July 1979, A.M. and M.J. Douglas.

### Paratypes

*Western Australia*

Same data as for holotype, 17 ♂, 1 ♀, ANIC, WAM; Boorabbin Rock (31°12'S, 120°17'E), 4-9 Oct. 1981, T.F. Houston, on flowers of *Melaleuca scabra* and *M. uncinata*, 2 ♀, WAM; Dulyalbin Rock, 30 Sept. 1972, W.M. O'Donnell, 1 ♀, WADA; 13 miles N of Geraldton, 19 Aug. 1971, T.F. Houston, on flowers of *Scholtzia spathulata*, 14 ♂, 1 ♀, WAM; Morawa, 3 Sept. 1978, A.M. and M.J. Douglas, ADAA, on flowers of *Hakea coriacea*, 5 ♂, WAM; 14 km SSW of Mt Jackson (30°15'S, 119°16'E), 24 Sept. 1982, B. Hanich and T.F. Houston, on flowers of *Wehlia thryptomenoides*, 5 ♀, ANIC, WAM; Mullewa, Sept., L.J. Newman, 2 ♀, WADA; 50 km E of Mullewa, 3 Sept. 1981, G.A. Holloway, 1 ♂, AM; 30 km W of Sandstone (27°59'S, 119°18'E), 7 Sept. 1981, T.F. Houston, on flowers of *Eucalyptus oldfieldii*, 2 ♂, WAM; 8 km NE of Tamala HS (26°42'S, 113°43'E), 21-23 Aug. 1980, C.A. Howard and T.F. Houston, on flowers of *Scholtzia drummondii*, 4 ♂, WAM; 8 km S of Yellowdine, 22 Oct. 1974, C.A. and T.F. Houston, on white flowers of *Grevillea*, 3 ♀, WAM.

### Diagnosis

Most like *C. centralis* and *C. nicholsoni* and unlike other species in combining the following features: integument of head and body black; metasomal terga with

erect, highly plumose, buff to rufous pubescence forming distinct transverse bands; eyes of male (except the smallest specimens) distinctly converging dorsally; mid tibial spur of female relatively broad with long coarse teeth (much as in Figure 20).

Differs from *centralis* and *nicholsoni* as follows: male with fore basitarsus normal (not attenuated and curved), fore and hind trochanters without ventral projections and facial pubescence rufous rather than buff; female with labrum densely pubescent beneath basal elevation (not bare unless worn), midventral margin of clypeus concave (Figure 12) rather than convex or trilobed, apical plate of hind femur almost wholly covered by dark brown pubescence (Figure 24; not at least half bare with golden setae over remainder), and pubescence of mesosternum wholly white (sooty in *nicholsoni*); both sexes with relatively shorter first segment of flagellum, equal in length to next 3½ or 4 segments combined (5 or 5½ in other species) and relatively smaller propodeal enclosure, large enough to accommodate only one ocellus (not 2 or 3 transversely).

## Description

*Male* (holotype)

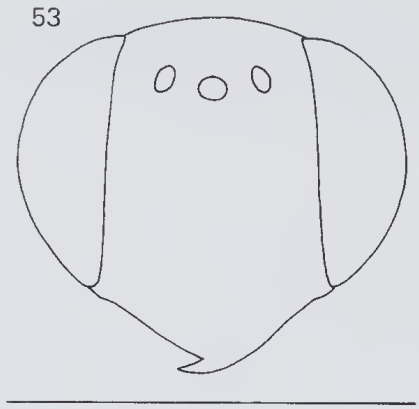
Body length 16 mm; head width 5.0 mm.

Relative dimensions: HW 100; HL 81, UID 21; LID 62; MOD 7; OOD 6; F1L 25; FRL 80.

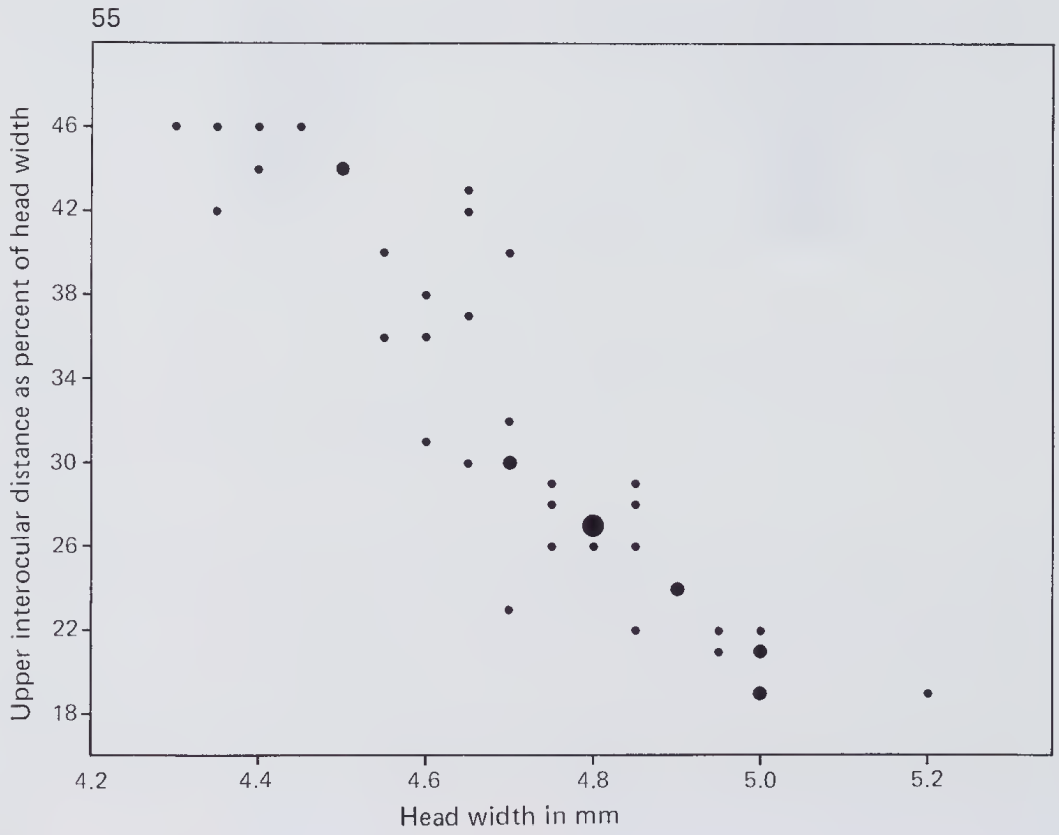
Head rounded viewed anteriorly; inner orbits strongly converging above; vertex narrow, level and depressed below level of tops of eyes; face much longer than wide; attenuated first segment of flagellum as long as next 3½ segments combined; first recurrent vein distal to first intercubitus by one-quarter posterior length of second cubital cell; propodeal enclosure obscured in type (in other specimens large enough to accommodate one or two ocelli); legs ordinary, without projections of trochanters, tibiae and basitarsi straight and not attenuated; fore tarsal claws symmetrical; fore calcar with moderate spine bearing several fine teeth; hind distitarsus (excluding claws) about 70% as long as distance from its insertion to base of segment 2; pygidial plate very narrow, projecting posteriorly.

Integument black except as follows: labrum, mandibles partially, legs from apices of femora to distitarsi, wing veins proximally and pygidial plate orange-brown; tegulae and hind margins of metasomal terga transparent pale brown.

Pubescence generally long, erect and fairly dense, more or less obscuring integument; golden-rust-coloured on face (including fringe across labrum), anterior margin of scutum, whole of metasomal tergum 2 except for lateral areas, broad apical bands on terga 3 and 4 and whole of metasomal segments 5 and 6; sterna 5 and 6 fringed with golden hair; labrum with a dense fringe of plumose setae arising under elevation; black on vertex, wide central band on scutum and another across scutellum and axillae, dorsolateral areas of metasomal tergum 2, wide bands right across terga 3 and 4, tegulae anteriorly and large diffuse patches








Figures 53-55 *Ctenocolletes rufescens* males: (53, 54) heads of smallest and largest individuals (anterior views; scale line = 5 mm); (55) scatter diagram showing relationship between sizes of individuals (judged by head width) and the degree of convergence of their compound eyes on the vertex (small spots represent one individual, medium spots two and the large spot four).

on mesepisterna from near tegulae to venter; tibiae with dark brown setae dorsally; remaining pubescence white.

Terminalia: see Figures 46-48.

Variation: males vary conspicuously in size (head widths range 4.3-5.2 mm, n 43). Associated with this variation is some morphological and chromatic variation.

Morphological variation occurs on the head where the degree to which the compound eyes converge on the vertex increases with overall size of the individual. While small males have relatively broad, gently convex vertices which exceed the tops of the eyes (Figure 53), larger males have progressively flatter, relatively narrower vertices which, in the largest individuals, may be depressed below the level of the compound eyes (Figure 54). The correlation between size and eye convergence is apparent from the scatter diagram (Figure 55).

Size-linked chromatic variation is seen in the intensity of the black patches of pubescence and their extent on the lateral and ventral areas of the mesothorax: larger males have more intense and more extensive black patches than smaller ones. The smallest individuals have predominantly white pubescence on mesosterna and mesopleura.

There also appears to be some age variation with the rufous pubescence of young males fading to almost a straw colour in older specimens.

*Female*

Body length 18-19 mm; head width 5.1-6.1 mm (n 15).

Relative dimensions: HW 100; HL 74-77; UID 51-55 (37 in one); LID 68-70; MOD 7; OOD 15-17 (12 in one); SL 13; F1L 22; FRL *c.* 57; C1L 18-20; C2L 24-26.

Vertex moderately convex viewed anteriorly; compound eyes slightly converging above and face between them a little wider than long; mid ventral margin of clypeus evenly concave (Figure 12); labrum about twice as wide as long with basal elevation occupying about half its length (Figure 12); mandibles long and slender (as in Figure 5; teeth frequently very worn); attenuated first segment of flagellum as long as next 4 to 4¼ segments together; first recurrent vein enters posterior margin of second cubital cell about one-third its length from first intercutibus; propodeal enclosure small, barely able to contain an ocellus; lateral portions of metasomal terga 3 and 4 ordinary (not bulbous nor concealing mites); pygidial plate fairly triangular (equilateral) with even, gently convex surface; mid tibial spur relatively broad (much as in Figure 20) with 10-17 long coarse teeth (n 20); inner hind tibial spur broad with 4-6 long coarse teeth (8 in one).

Integument predominantly black and non-metallic; hind margins of metasomal terga broadly translucent brown; mandibles, distitarsi, tibial spurs, tegulae and parts of venation brown.

Pubescence generally long and dense, obscuring most of integument; white on posterior of head, lateral and ventral areas of thorax, propodeum, first metasomal tergum and sterna 1-3, basal portions of legs and outer ventral portion of hind

tibial scopa; light buff on face (except vertex and areas lateral to ocelli), dense plumose fringe arising under labral elevation, and dorsum of thorax (except for sooty areas); apical margins of metasomal terga 2-4 with adpressed golden to rich orange pubescence; terga 5 and 6 wholly covered by long dense deep orange hair; sterna 4-6 with long apical fringes grading from faint to rich orange; sooty brown on vertex, areas lateral to ocelli, large patch on mid scutum extending narrowly each side in front of tegulae, smaller patches on axillae, scutellum, dorsolateral corners of propodeum, tegulae, and upper mesepisterna, dorsal surfaces of all tibiae, and basitarsi; metasomal terga 2-4 (except margins) with very short sparse black pubescence.

### Distribution

Southern Western Australia (Figure 6).

### Remarks

The sexes are associated on the basis of morphological and chromatic similarities and coincident collection records.

The specific epithet is Latin for 'becoming red' in allusion to the rusty-coloured pubescence.

## *Ctenocolletes smaragdinus* (Smith, 1868)

Figures 3, 7, 14, 18, 56

*Stenotritus smaragdinus* Smith, 1868: 254 (female).
*Melitribus smaragdinus* (Smith) Rayment, 1930a: 11.
*Ctenocolletes smaragdinus* (Smith) Michener, 1965: 83, figures 214-216.
*Melitribus glauerti* Rayment, 1930a: 16-17 (female). Syn. nov.
*Stenotritus glauerti* (Rayment) Rayment, 1930b: 60.
*Stenotritus (Ctenocolletes) glauerti* (Rayment) Rayment, 1935: 194-195.
*Ctenocolletes glauerti* (Rayment) Michener, 1965: 83.
*Stenotritus speciosus* Rayment, 1935: 683, pl. 26, Figures 25, 26 (male). Syn. nov.
*Ctenocolletes speciosus* (Rayment) Michener, 1965: 83.


**Figure 56** *Ctenocolletes smaragdinus* male (left) and female.

Types

Holotype of *smaragdinus:* ♀, Champion Bay [28°46'S, 114°36'E], Western Australia, in BM. See remarks under Distribution.

Holotype of *glauerti:* ♀, Yorkrakine [31°22'S, 117°35'E], Western Australia, in WAM (1919/224).

Holotype of *speciosus:* ♂, Dowerin [31°12'S, 117°02'E], Western Australia, L.J. Newman, in ANIC.

## Diagnosis

Immediately distinguishable from all other species by its brilliantly metallic green integument and sparse pubescence.

## Description

*Male*

Body length 14.0-16.5 mm; head width 4.8-5.3 mm (n 29).

Relative dimensions: HW 100; HL 81-84; MFW 44-46; LID 58-59; MOD 7.0-7.5; OOD 10-11; SL 13-14; F1L 22-24; FRL 80-85; ML 38-40; MBW 13.

Inner margins of eyes bowed medially; face narrowest just below level of antennal sockets where it is about two-thirds as broad as eye length; vertex broad and distinctly elevated above summits of eyes; labrum much as in female (Figure 14) but with basal elevation longer; mandible slender with short posterior tooth; attenuated first segment of flagellum as long as next 3¼ segments together; tegulae unevenly convex; first recurrent vein distal to first intercubitus by one-third to one-half posterior length of second cubital cell; propodeal enclosure just large enough to just too small to accommodate an ocellus; pygidial plate smooth with even surface; legs without conspicuous modifications; hind distitarsus (excluding claws) slightly longer than distance from its insertion to base of segment 2; apical (eighth) metasomal sternum produced posteriorly into a large curved spine.

Integument predominantly brilliant metallic green, mostly shagreened but fairly shiny on more apical metasomal terga. The following are black or black-brown: eyes, ocelli, mandibles (except bases), labrum, antennae (except scapes), tegulae posteriorly, pygidial plate and distitarsi.

Pubescence relatively sparse and inconspicuous above, longest and densest on underparts and propodeum, predominantly white; black-brown on vertex, scutum (except margins), scutellum and axillae, small patch posterior to pronotal tubercles, tegulae, metasomal terga 3-7 and 2 apically, and legs (partially) beyond femora.

Terminalia: figured by Michener (1965: 84).

*Female*

Body length 17-19 mm; head width 5.6-6.2 mm (n 10).

Relative dimensions: HW 100; HL 81-83; MFW 54-55; LID 67-70; MOD 6-7; OOD 16; SL 13-14; F1L 22-23; FRL 56-59; ML 45-46; MBW 15-16; C2L 25-26.

Head moderately broad; inner margins of eyes slightly converging above, face narrowest above level of ocelli, about as wide as long between eyes; vertex strongly elevated above summits of eyes, rather level medially; midventral margin of clypeus transverse to gently convex; labrum half as long as wide, ventral margin indented, basal elevation broadly carinate but very short and mainly hidden under clypeus when labrum is protracted (Figure 14); mandible moderately slender, broadened subapically, anterior tooth porrect, posterior tooth moderately short (when unworn); attenuated first segment of flagellum as long as next 4.2 segments together; tegulae with pronounced swellings and narrow flange-like margin anteriorly; wing venation and propodeal enclosure as in male; lateral portions of metasomal terga 3 and 4 ordinary (not swollen nor concealing mites); pygidial plate with even surface; mid tibial spurs long and slender with 12-16 short to very short teeth (n 17; Figure 18); inner hind tibial spurs moderately elongate with 4-8 long coarse teeth (n 17).

Integument much as in male but less shiny on metasoma; a conspicuous black non-metallic foveal patch on each side of face between lateral ocellus and eye margin; a similar but larger foveal patch on each side of second metasomal tergum.

Pubescence much as in male but sparser, especially the blackish setae on thorax; metasomal terga 2-4 with minute black setae, 5 and 6 with long, dense black hair apically; metasomal foveae with buff tomentum visible only in oblique light; hind femoral apices covered by dense black hair; hind tibial scopa mainly white, blackish dorsally; sterna 2-4 with fringes of long, white hair.

### Distribution

South-western Australia (Figure 7). The outlying records from Champion Bay (Geraldton) and Busselton are based on single specimens and while not improbable should perhaps be regarded with some reservation.

### Remarks

It appeared unnecessary to examine the type of *smaragdinus*. Rayment (1930*a*) differentiated *glauerti* from *smaragdinus* on the grounds that it was larger and lacked dorsal fringes of white hair on the abdomen. However, in Smith's original description of the latter species the only white abdominal fringes mentioned are ventral ones. In describing *speciosus*, Rayment (1935) suggested it might be the male of *glauerti*. That this is so has now been confirmed by capture of mating pairs.

#### Material Examined

The holotypes of *glauerti* and *speciosus* and the following.

*Western Australia*

10 km S of Aldersyde, E of Pingelly, Oct. 1977, T. White, 1 ♂, WAM; Boorabbin Rock (31°12'S, 120°17'E), 4-9 Oct. 1981, T.F. Houston, on flowers of *Verticordia chrysantha*, 3 ♂,

WAM: Bruce Rock, Oct. 1952, A. Douglas, 1 ♂, WAM; Busselton, 11 Feb. 1970, S.J. Curry, 1 ♂, WADA; near Emu Rock (32°27'S, 119°25'E), 53 km E of Hyden, 9-14 Oct. 1979, T.F. Houston (on flowers of *Leptospermum erubescens*, 1 ♂; on flowers of *Melaleuca microphylla*, 1 ♀; ex sleeping aggregation on *Casuarina* shrub, 14 ♂; on flowers of *M. scabra*, 1 ♀; *in copula* on heath shrub, 1 ♂, 1 ♀), WAM; Glen Eagle, 21 Nov. 1972, K.T. Richards, 1 ♀, WADA; 16 miles E of Lake Grace, 29 Sept. 1952, Key and Wallace, 1 ♀, ANIC; 'Laverton' [in error according to collector], 12 July 1967, K.T. Richards, 1 ♀, WADA; 5.5-6.6 km SW of McDermid Rock (32°01'S, 120°44'E), 27 Sept.-3 Oct. 1978, T.F. Houston *et al.* (on flowers of *Verticordia chrysantha*, 4 ♂; on flowers of *Grevillea biformis*, 1 ♀; on flowers of *Melaleuca leptospermoides*, 1 ♀), WAM; Merredin, 2 ♂, ANIC, WAM; Mt Walker School turn-off, 8 Sept. 1969, P.N. Forte, 8 ♀, WADA; Narrogin, 37-3862, 1 ♀, ANIC; Northam, Jessup Coll., 1 ♀, AM; 50 miles E of Southern Cross between no. 7 tank and no. 7 pump, 9 Oct. 1978, D. Knowles, 1 ♀, WAM; Tutanning Reserve, 18-25 km E of Pingelly, 30 Oct.-3 Nov. 1980, T.F. Houston, on flowers of *Verticordia picta*, 1 ♂, 1 ♀, WAM; Yellowdine (3.5-5.5 km S of, 27 Oct. 1978, on flowers of *Baeckea leptospermoides*, 1 ♀; 8 km S of, 22 Oct. 1974, on flowers of *Verticordia picta*, 2 ♀), T.F. Houston, WAM.

## *Ctenocolletes tricolor* sp. nov.

Figures 6, 15, 29, 30, 43-45, 57

*Ctenocolletes albomarginatus* Michener, 1965: 266 (part).


Figure 57 *Ctenocolletes tricolor* male (left) and female.

Holotype

In WAM (82/128), ♂, 8 km S of Yellowdine [31°18'S, 119°39'E], Western Australia, 22 Oct. 1974, C.A. and T.F. Houston, on white flowers of *Grevillea*.

Paratypes

*Western Australia*

Boorabbin Rock [31°12'S, 120°17'E], 4-9 Oct. 1981, T.F. Houston, on flowers of *Melaleuca scabra*, 1 ♀, WAM; Merredin [but see Michener 1965: 266], A. Douglas, 'Paratype *Ctenocolletes albomarginata* C.D. Michener', 1 ♀ [also bears an unpublished Rayment manuscript

name in the genus *Anthoglossa* meaning golden pygidium], WAM; reserve 6 km ENE of Merredin, 29 Oct. 1978, T.F. Houston, on flowers of *Grevillea paradoxa*, 1 ♂, WAM; Moorine Rock, Sept. 1952, D.L. McIntosh, 'Paratype *Ctenocolletes albomarginatus* C.D. Michener', 1 ♂, 1 ♀, ANIC; 14 km SSW of Mt Jackson (30°15'S, 119°16'E), 24 Sept. 1982, B. Hanich and T.F. Houston, on flowers of *Wehlia thryptomenoides*, 1 ♀, WAM; same data as for holotype, 6 ♂, WAM.

## Diagnosis

Most like *C. albomarginatus* (see diagnosis for that species).

## Description

*Male* (holotype)

Body length *c.* 18 mm; head width 5.4 mm.

Relative dimensions: HW 100; HL 80; UID 39; LID 58; MOD 8; OOD 9.5; SL 12; F1L 23; FRL *c.* 87; ML 40; MBW 12.5.

Inner margins of eyes more or less parallel, face between them much longer than wide; vertex only slightly convex viewed anteriorly and scarcely exceeding summits of eyes; labrum somewhat like that of female (Figure 15) but basal elevation smaller, occupying only one-third of its length; mandible slender with large acute posterior tooth and small blunt anterior tooth; attenuated first segment of flagellum as long as next three segments together; first recurrent vein distal to first intercubitus by two-fifths posterior length of second cubital cell; propodeal enclosure extremely small, unable to accommodate an ocellus, and narrowing posteroventrally to less than half minimum thickness of first flagellum segment; pygidial plate swollen and wrinkled anteriorly; legs lacking conspicuous modifications except for unequal fore tarsal claws (inner claw longer and modified; Figures 29, 30); hind distitarsus (excluding claws) 85% as long as distance from its insertion to base of segment 2; last visible (eighth) metasomal sternum strongly concave and bidentate apically (Figure 44).

Integument black generally, moderately shiny and non-metallic (metasomal terga are faintly iridescent). Labrum, mandibles distally, fore legs beyond and including femoral apices and pygidial plate orange-brown to red-brown.

Pubescence generally long, dense, erect and obscuring integument (except on metasomal terga). White as follows: on head posteriorly, thorax (except dark patches to be noted), propodeum, first two metasomal terga, narrow apical fringes on terga 2 and 3, sterna 1-4 (and 5 laterally), legs proximally to apices of femora, and ventral margins of hind tibiae. Rich golden hair covers face (except vertex, areas lateral to ocelli and midline of clypeus) and spreads from supraclypeal area; a weak fringe beneath labral elevation. Sooty brown to black pubescence occurs as follows: on vertex, broad band across scutum and another across scutellum and axillae, tegulae, diffuse patches posterior to pronotal tubercles, over metasomal terga 3-7 (longest on distal terga), dorsally on tibiae and over tarsi generally.

Terminalia: see Figures 43-45.

Variation: size variation appears slight, the range of head widths being 5.0-5.4 mm (n 8). Little discernible variation occurs in head form (upper interocular distance varies from 39-45% of head width). In most specimens the pale pubescence across the anterior margin of the scutum is distinctly buff and the labrum in one is almost black.

*Female* (paratype WAM 82/136)

Body length 19 mm; head width 6.0 mm.

Relative dimensions: HW 100; HL 78; UID 53; LID 68; MOD 8; OOD 17; SL 13; F1L 22; FRL *c.* 60; ML 48; MBW 14; C2L 22.

Head moderately broad; vertex only slightly elevated above summits of eyes and face between eyes about as broad as long; midventral margin of clypeus slightly unevenly concave; labrum (Figure 15) with basal elevation occupying about half its length; mandible slender with moderately long acute posterior tooth; attenuated first segment of flagellum as long as next 3.7 segments together; wing venation and propodeal enclosure as in male; lateral portions of metasomal terga 3 and 4 ordinary (not bulbous, translucent and concealing mites); pygidial plate with smooth gently convex surface; mid tibial spurs relatively short and broad with 13 long coarse teeth; inner hind tibial spurs very broad with 5 and 6 long coarse teeth (plus 1 or 2 smaller ones).

Integument predominantly black and non-metallic with elevation of labrum, tibial spurs and pygidial plate orange-brown.

Pubescence of head, mesosoma and first 4 metasomal terga much as in male; fifth and sixth metasomal terga with long, very dense orange hair; metasomal sterna with long apical fringes becoming increasingly more orange from first to sixth; all tibiae with pubescence white ventrally and dark brown dorsally.

Variation: in two other paratypes mid tibial spurs have 13-15 teeth and inner hind tibial spurs 4-6 coarse teeth (plus 4 or 5 finer ones).

**Distribution**

Southern Western Australia, confined as far as known to an area (Figure 6) spanning only about 200 km.

Remarks

The sexes are associated on the basis of similar features of pubescence, coincident collection records and correlation of characters with those of the near species *albomarginatus.*

The specific epithet alludes to the three distinct colours of the pubescence.

## Discussion

The morphological characters of the species were analysed cladistically. The closeness of *centralis* to *nicholsoni* and *albomarginatus* to *tricolor* is obvious, but the affinities of the remainder are not. A proper understanding of the species' relationships is required to form a framework for discussion of behavioural traits in a forthcoming paper. Additionally, it is useful to identify the ancestral character states of *Ctenocolletes* so that its relationship to *Stenotritus* may become clearer.

Results of the analysis are presented graphically in Figure 58. The cladogram was devised to account for the greatest number of shared, presumed derived character states as was possible. The characters utilized are listed in Table 2 with presumed derived and ancestral states (for 2 and 12 more than one derived state is recognized). One difficulty in constructing the cladogram was that only female characters for a unique type were available for *fulvescens* and discovery of the male may place it differently in the scheme.

There are several character states whose distribution amongst the species does not support the cladogram (see top of Figure 58). These states were presumed to be derived and, if this is so, their presence in unrelated species has to be attributed to parallel evolution. Alternatively, the states may be ancestral ones which have been retained in these species but lost (or modified) in their congeners. The polarity of character states or gradients was deduced initially (and in some cases very tentatively) by comparisons with the states prevailing within the genus, the family and the superfamily.

Character 1 was a difficult case. Convergence of the eyes on the vertex in males is a relatively uncommon feature in bees and was considered derived within the Apoidea. It characterizes most *Stenotritus* and all but two *Ctenocolletes* whose males are known. Consequently, it would be logical to propose that convergent male eyes is an ancestral character state of the Stenotritidae and that reversion to the ancestral apoidean state has occurred in those species with more parallel eyes. Alternatively, convergent eyes may have arisen independently in *Stenotritus* and clade D of *Ctenocolletes*.

Character 4 also posed problems. Compared with most bees, the stenotritids have a small enclosure. In *Stenotritus* and some *Ctenocolletes* the enclosure is of a fairly uniform, moderately small size (which may be an ancestral state) but in several *Ctenocolletes* it is very much smaller. Ought this tiny enclosure be regarded as derived because it culminates a trend to reduction, or should it be viewed as representing an ancestral condition in the genus with the moderate enclosures of some species representing a derived, reversionary state? Given the relationships inferred from cladistic analysis I believe it would be more parsimonious to adopt the latter view. Reversion to a moderate enclosure is suggested for clade B and (probably independently) for *fulvescens*. Otherwise it is necessary to propose that a tiny enclosure has arisen independently in *rufescens* and clades C and E.

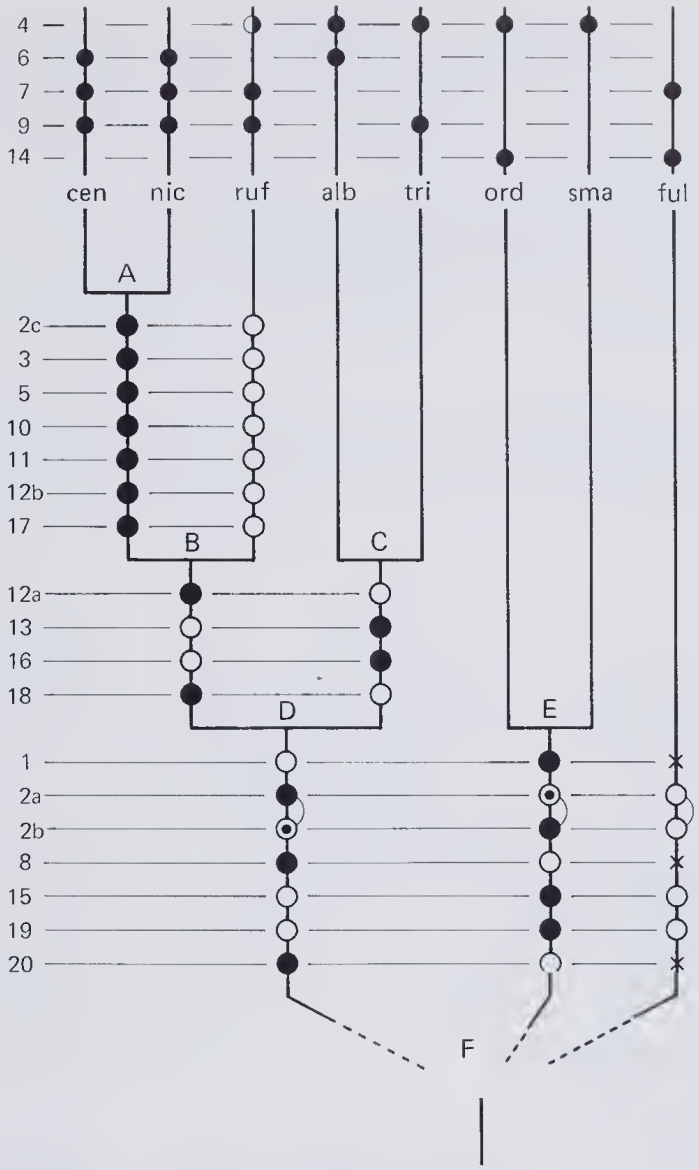



Figure 58 Cladogram showing inferred interrelationships of the species of *Ctenocolletes*. Species names are abbreviated (e.g. 'cen' = *centralis*). Solid circles represent presumed synapomorphies supporting clades above them. Open circles represent presumed ancestral states in sister groups or species. Open circles with solid centres indicate an alternative derived state (represented by solid circle linked by arc). Crosses on *fulvescens* line indicate that male character states are unknown. Solid circles at top of diagram represent presumed derived character states not supporting cladogram (half-solid circle indicates state applies only to one sex). Characters and their states may be identified by numbers on left which correlate with those of Table 2. Letters (A-F) are to facilitate discussion of particular clades.

Similarly, the lateral tergal convexities of females that often contain mites (character 6) were initially viewed as possibly synapomorphous. However, given the inferred species' relationships, I would now have to propose that either the state is ancestral for clade D and the convexities have been lost from *rufescens* and *tricolor* independently, or it was derived independently in clade A and *albomarginatus*. I remain equivocal as to these possibilities.

The ancestor of *Ctenocolletes* would presumably have exhibited most of the ancestral states listed in Table 2 (taking the first alternative where more than one is listed). As explained, doubt exists as to which states are ancestral for characters 1, 4 and 6.

Table 2 Characters for cladistic analysis. Identification of the derived and ancestral states of each character preceded cladistic analysis and the cladogram devised gives cause to review some identifications (see text for further explanation).

| Character | Derived state | Ancestral state |
|---|---|---|
| 1 Compound eyes of male | Not converging on vertex | Converging on vertex (at least in large males) |
| 2 Ventral flange of labrum (especially in female) | (a) Longest medially, semicircular to rather triangular | (a) Short and transverse |
| | (b) Rather trapezoidal, ventral margin emarginate | (b) As for (a) |
| | (c) Rather triangular | (c) More semicircular |
| 3 Length of first segment of flagellum of male as percent of head width | More than 30% | 22-25% |
| 4 Size of propodeal enclosure relative to an ocellus | Able to accommodate one or less | Able to accommodate more than one |
| 5 Distance between 1st recurrent and 1st intercubital veins as fraction of posterior width of 2nd cubital cell | 1/4 or less | 1/3 to 1/2 |
| 6 Lateral portions of metasomal terga 3 and 4 of female | Convex, translucent to transparent, and hollow beneath (often with mites) | Even, not convex, not hollow beneath (without mites) |
| 7 Posterior and lateral margins of metasomal terga | Transparent | Opaque |
| 8 Apex of 8th metasomal sternum of male | With broad obtuse prominence, indented or excavated medially | With narrow prominence, neither indented nor excavated medially |
| 9 Width of mid tibial spur of female (including teeth) as percent of length | 20% or more | Less than 20% |

Table 2 (continued)

| Character | Derived state | Ancestral state |
|---|---|---|
| 10 Ventral processes of fore trochanters of male | Present | Absent |
| 11 Fore basitarsi of male | Attenuated, arcuate and expanded distally | Normal (straight and uniformly thick) |
| 12 length of hind distitarsus of male (excluding claws) as percent of distance from its insertion to base of segment 2 | (a) Less than 75%<br>(b) Less than 60% | (a) At least 75%<br>(b) At least 60% |
| 13 Fore tarsal claws of male | Unequal and dissimilar | Equal and alike |
| 14 Patches or bands of blackish setae on mesothorax (especially scutum) | Absent | Present |
| 15 Fringes of pale pubescence across posterior margins of metasomal terga 2-5 | Absent | Present |
| 16 Colour of marginal hair bands of metasomal terga 1-4 of female | White, contrasting sharply with rufous hair of terga 5 and 6 | Buff, not contrasting with but grading into rufous hair of terga 5 and 6 |
| 17 Apical plate of hind femur of female | At least half bare | At least 3/4 covered by hair |
| 18 Hair of metasomal terga 3-6 (chiefly in male) | Mostly soft, erect and highly plumose | Mostly stiff, reflexed, simple or only slightly plumose |
| 19 Hair of metasomal terga 5 and 6 of female | Black | Buff or rufous |
| 20 Dorsal processes of penis valves of male compared with apical extensions | Much larger | Much smaller |

## Acknowledgements

I am grateful to the following people for allowing me access to the collections in their care, for assistance and for the loan of specimens: Dr C. Smithers and Mr G. Holloway (AM), Dr I. Naumann and Ms J. Cardale (ANIC) and Mr K. Richards (WADA).

## References

Cockerell, T.D.A. (1929). Descriptions and records of bees. CXV. *Ann. Mag. nat. Hist.* (10) 3: 354-360.

McGinley, R.J. (1980). Glossal morphology of the Colletidae and recognition of the Stenotritidae at the family level (Hymenoptera: Apoidea). *J. Kans. ent. Soc.* 53: (3): 539-552.

Michener, C.D. (1944). Comparative external morphology, phylogeny, and a classification of the bees (Hymenoptera). *Bull. Am. Mus. nat. Hist.* 82: 151-326.

Michener, C.D. (1965). A classification of the bees of the Australian and South Pacific regions. *Bull. Am. Mus. nat. Hist.* 130: 1-362, pls 1-15.

Rayment, T. (1930*a*). Studies in Australian bees. *Victorian Nat.* 47: 9-17.

Rayment, T. (1930*b*). New and remarkable bees. *Proc. R. Soc. Vict.* 43: 42-61.

Rayment, T. (1935). A Cluster of Bees. (Endeavour Press: Sydney.)

Smith, F. (1868). Descriptions of aculeate Hymenoptera from Australia. *Trans. R. ent. Soc. Lond.* (3) 2: 231-258.

Received 27 August 1982 Accepted 2 November 1982 Published 20 April 1983